Municipal Zero Net Energy
Project Engineering as Reach Code Technical Assistance

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Heather Larson, Green Building in Alameda County
Erik Pearson, Environmental Services Manager City of Hayward
Bruce Playle, Indigo Architects for City of Dublin Public Safety project
Presentation Overview

- Municipal ZNE Technical Assistance
- Case Studies
  - City of Hayward- Portfolio /Policy
  - City of Dublin- Campus Project
2016 Bay REN C&S ZNE Reach Code projects led by 3 counties

- San Francisco
  - ZEPI Non-Residential Definition
- San Mateo
  - ZNE policy templates & City engagement
- Alameda
  - Municipal ZNE Technical Assistance
    - Engineering
    - Cost estimating
    - Portfolio review
    - Training
Green Building Grants & Technical Assistance

• **Historical Reach Codes in Alameda County (2000-2015)**
  - Prior to CAL Green State Code taking effect
    - **Civic** green building reach-code policies in every jurisdiction
    - Majority of jurisdictions had **private sector** reach code green building requirements
  - Climate Action Plans adopted in all 15 jurisdictions, first County in State
Alameda County approach to reach codes:  
*Lead by Example* on municipal buildings to prime the market for ZNE policies (municipal -> commercial -> residential)
Technical Assistance (TA) addresses lacking in-house LG engineering capacity

- Project-specific systems engineering & cost analysis to lower energy use intensities (EUI), size renewables & integrate storage
  - Modeling for optimized gas vs. electric system design
- Community scale ZNE defined by a jurisdiction’s municipal energy usage portfolio
- Local government trainings (2 audiences):
  - Targeted to code enforcement staff
  - Targeted to public works, engineering & facilities staff who will be designing & operating municipal ZNE facilities
Municipal ZNE projects & policies

- Receiving TA in 2016
  - City of Berkeley
  - City of Dublin- Campus project case study
  - City of Hayward- Policy/Portfolio project case study
  - City of Oakland
  - County of Marin
  - City of West Marin
  - County of Alameda

- To Request Municipal ZNE Engineering assistance in 2017
  email: codes@bayren.org
The Oakland 911 Dispatch Center in Oakland, California is approximately 11,700 square feet dispatch facility. The scope of the net zero feasibility analysis only includes the single building.
Berkeley Recreation Center

- Energy & Resiliency analysis
  - Sports lighting LED retrofit
  - Heating system fuel switch
  - Heat Pump hot water heaters
  - Induction range
  - LED lighting replacement
  - BMS system
  - Roof insulation
  - Natural Ventilation upgrades
  - Battery Storage
  - Solar PV System
City of Hayward
City staff working on Municipal ZNE ordinance
adopted 2016
ZNE Library Under Construction
NR-4.10 Public Renewable Energy Generation: The City shall ensure that all new City-owned facilities are built with renewable energy, as appropriate to their functions, and shall install renewable energy systems at existing facilities where feasible.
City of Hayward passed a Municipal ZNE Ordinance April 2016

- City of Hayward is 1 of 3 total jurisdictions in CA w/ a ZNE ordinance as of Q3 2016 (Santa Barbara & Palo Alto)
- Community Scale ZNE for Municipal Portfolio
- Current municipally owned generation (Solar + co-gen at wastewater treatment plant = 12,387,000 kWh per year) meets ~1/2 of municipal energy usage
City of Hayward
City of Hayward

Summary of assistance on ordinance

- Can we go full Municipal ZNE by 2025?
  - Can we do it sooner?
- Validate solar potential assumptions
- Is it cost effective?
- What rate tariff?
- How to deal with Gas?
Renewable Energy at Hayward’s Water Pollution Control Facility
City of Hayward

Past

Future

Municipal Energy Use: 21.8 GWh
- Biogas: 9.4 GWh
- Cogen: 2.4 GWh
- Wastewater Solar: 0.6 GWh
- Distributed Solar: 14.0 GWh
- Remaining 2016: 0.4 GWh
- LED Retrofit: 0.6 GWh
- Other EE: 8.6 GWh
- Solar Potential: 4.4 GWh

Remaining Gas: 4.6 GWh
What about remaining gas load?

- Install a 2nd Cogeneration Engine
- Electrify Municipal Buildings
- Wheel Gas through PG&E Piping
- Truck to CNG Storage Tanks
- Create CNG Vehicle Fuelling Station
Bill Credit Transfer Analysis

Should we actually be aiming for 2020?

105.25 MW Cap Limit for PG&E territory wide
# City staff generation analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Address</th>
<th>Square Feet</th>
<th>kW</th>
<th>kWh/year</th>
<th>2015 Usage (kWh)*</th>
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</thead>
<tbody>
<tr>
<td>Police Station</td>
<td>390 West Winton Avenue</td>
<td>23,000</td>
<td>145</td>
<td>604,440</td>
<td>928,718</td>
</tr>
<tr>
<td>Muni Lot (A, B, Main, Mission)</td>
<td>21550 Mission</td>
<td>10,000</td>
<td>150</td>
<td>262,800</td>
<td></td>
</tr>
<tr>
<td>Muni Lot (Foothill, A, Main, B) - access from A St.</td>
<td>1025 A St.</td>
<td>12,500</td>
<td>188</td>
<td>328,500</td>
<td></td>
</tr>
<tr>
<td>Muni Lot (Foothill, A, Main, B) - access from B St.</td>
<td>1042 B, &amp; S more APNs</td>
<td>20,000</td>
<td>100</td>
<td>525,600</td>
<td></td>
</tr>
<tr>
<td>Muni Lot (B, C, Foothill, 2nd)</td>
<td>Foothill &amp; B</td>
<td>16,000</td>
<td>240</td>
<td>420,480</td>
<td></td>
</tr>
<tr>
<td>Muni Lot (Maple Ct. &amp; A St.)</td>
<td>22456 Maple Ct. (north half)</td>
<td>16,750</td>
<td>251</td>
<td>440,190</td>
<td></td>
</tr>
<tr>
<td>Muni Lot (Foothill, Russell, 2nd, A)</td>
<td>Foothill &amp; A</td>
<td>12,000</td>
<td>180</td>
<td>315,360</td>
<td></td>
</tr>
<tr>
<td>Cinema Parking Structure</td>
<td>22695 Foothill</td>
<td>10,100</td>
<td>152</td>
<td>265,428</td>
<td>68,126</td>
</tr>
<tr>
<td>Barnes Ct. bldg (add more on roof)</td>
<td>16 Barnes Ct.</td>
<td>7,000</td>
<td>105</td>
<td>193,960</td>
<td></td>
</tr>
<tr>
<td>Barnes Ct. (carport to replace tent at rear of site)</td>
<td>16 Barnes Ct.</td>
<td>4,500</td>
<td>68</td>
<td>118,260</td>
<td></td>
</tr>
<tr>
<td>Fleet Bldg.</td>
<td>24505 Soto Road</td>
<td>2,600</td>
<td>39</td>
<td>68,328</td>
<td>80,950</td>
</tr>
<tr>
<td>Fire Station 1 (assuming carport - roof doesn’t look good)</td>
<td>22700 Main Street</td>
<td>5,400</td>
<td>81</td>
<td>141,912</td>
<td>141,457</td>
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<tr>
<td>Fire Station 2</td>
<td>360 West Harder Rd</td>
<td>1,000</td>
<td>15</td>
<td>26,280</td>
<td>35,732</td>
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<tr>
<td>Fire Station 3</td>
<td>31982 Medinah St</td>
<td>550</td>
<td>0.3</td>
<td>14,454</td>
<td>33,060</td>
</tr>
<tr>
<td>Fire Station 4</td>
<td>27836 Loyola Ave</td>
<td>650</td>
<td>9.8</td>
<td>17,082</td>
<td>36,413</td>
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<tr>
<td>Fire Station 5</td>
<td>21595 Harward Blvd</td>
<td>880</td>
<td>13.2</td>
<td>23,126</td>
<td>40,810</td>
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<tr>
<td>Fire Station 6</td>
<td>1401 West Winton Ave</td>
<td>1,500</td>
<td>22.5</td>
<td>39,420</td>
<td>120,938</td>
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<tr>
<td>Fire Station 7</td>
<td>22270 Huntwood Ave</td>
<td>2,000</td>
<td>30</td>
<td>52,560</td>
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<tr>
<td>Fire Station 9</td>
<td>24812 Second St</td>
<td>800</td>
<td>9.0</td>
<td>15,700</td>
<td>30,573</td>
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<tr>
<td>City Hall</td>
<td>777 B St.</td>
<td>4,190</td>
<td>63</td>
<td>110,113</td>
<td>1,191,355</td>
</tr>
<tr>
<td>Watkins Street Parking Structure (2nd half)</td>
<td>Watkins &amp; B</td>
<td>14,600</td>
<td>203.0</td>
<td>495,816</td>
<td></td>
</tr>
<tr>
<td>2nd Cogen engine at WPCF</td>
<td>3700 Enterprise Way</td>
<td>100</td>
<td>700,000</td>
<td>2,352,936</td>
<td></td>
</tr>
<tr>
<td>Phase 2 Solar PV at WPCF</td>
<td>3700 Enterprise Way</td>
<td>1,000</td>
<td>7,000,000</td>
<td>2,352,936</td>
<td></td>
</tr>
<tr>
<td>Hesperian Pump Station - roofed canopy</td>
<td>22471 Hesperian Bl</td>
<td>11,000</td>
<td>105</td>
<td>259,000</td>
<td>169,100</td>
</tr>
<tr>
<td>Walpert pump reservoir/station</td>
<td>1241 Walpert St.</td>
<td>7,500</td>
<td>113</td>
<td>197,100</td>
<td>262</td>
</tr>
<tr>
<td>500 Reservoir</td>
<td>1910 Highland Blvd</td>
<td>4,700</td>
<td>71</td>
<td>123,516</td>
<td>796,462</td>
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<tr>
<td>750 Reservoir</td>
<td>26635 Parkside Dr</td>
<td>7,500</td>
<td>113</td>
<td>197,100</td>
<td>740,618</td>
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<tr>
<td>1000 Reservoir</td>
<td>3466 La Mesa Drive</td>
<td>1,200</td>
<td>18</td>
<td>31,536</td>
<td>456,309</td>
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<tr>
<td>1283 Reservoir</td>
<td>23750 Fairview Ave</td>
<td>2,600</td>
<td>59</td>
<td>68,328</td>
<td>290,520</td>
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<tr>
<td>May Road (adjacent to Treeview Reservoir)</td>
<td>037-0040-004-04</td>
<td>20,000</td>
<td>300</td>
<td>525,600</td>
<td></td>
</tr>
<tr>
<td>Garin Reservoir</td>
<td>083-0464-024-00</td>
<td>6,800</td>
<td>102</td>
<td>178,704</td>
<td></td>
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<tr>
<td>Emergency Well E (Old Well 9)</td>
<td>21251 Industrial Bl</td>
<td>1,300</td>
<td>20</td>
<td>34,164</td>
<td></td>
</tr>
<tr>
<td>Mohrland Emergency Well</td>
<td>24927 Mohr Dr</td>
<td>5,300</td>
<td>80</td>
<td>139,284</td>
<td></td>
</tr>
</tbody>
</table>

**Additional Possibilities:**
- Airport Property
- Area between City Hall and BART
- Centennial Hall Parking Structure

kWh needed to zero out electricity use: 9,392,958
Difference: 6,222,268

kWh needed to go carbon neutral (incl. nat gas): 13,997,460
Difference: 1,617,765
Solar Potential
Refinement of generation analysis
City of Dublin –
Project Architect for Public Safety Complex
City of Dublin Public Safety Complex
Façade with 50’s styling....

...and old school single-glazing
Sustainability goals

- This public facility will be designed, built and operated using green building principles demonstrating leadership by example.

- Visible public projects that highlight the beauty and value of green building, raise awareness, encourage the private sector to build green.

- Promote local market transformation by demonstrating best practices in government owned buildings.
Resiliency goals

- Building must adapt to emergency conditions, quickly regaining functionality during and long after disaster or power outages.

- Conserve energy usage to extend e-power system availability, reduce amount of PV required for ZNE offset.

- Take advantage of resilient measures for LEED compliance and to improve the daily work environment. Examples:
  - Natural lighting.
  - Natural ventilation.
Zero Net Energy

- BayRen/ DNV GL came in during schematic design phase.
- Presentation to Dublin City Council, ZNE defined.
- Recommended Energy Conservation Measures.
- Helped predict energy use.
- Reviewed potential funding sources.
- Helped integrate the ZNE work with LEED, CalGreen and PG&E Savings-by-Design program.
Recommended ECMs

Typical domestic hot water systems include electric water heater or natural gas water heater, including an expansion tank, which incur standby loss. Heat Pump Water Heater (HPWH) is an emerging technology that extracts heat from air to heat the water. Due to its high efficiency, it is recommended instead of electric tank-less water heater. Even federal regulation requires heat pump water heater where electric heaters are to be installed in commercial facilities where the rated storage volume are above 55 gallons.

<table>
<thead>
<tr>
<th>Efficiency (COP)</th>
<th>Electric Water Heater</th>
<th>Natural Gas Water Heater</th>
<th>Heat Pump Water Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantage</td>
<td>Easy to Install, Safer, Lower Capital Cost</td>
<td>Faster Recovery Rate, Convenient for Larger Load</td>
<td>Highest Efficiency</td>
</tr>
<tr>
<td>Disadvantage</td>
<td>More Costly where Electric Prices are Higher</td>
<td>Lower Efficiency</td>
<td>May Require Isolation from Conditioned Heated Areas</td>
</tr>
</tbody>
</table>

Heating, Ventilation, and Air Conditioning (HVAC) system is one of the major end use consumptions. Selection of specific system is critical to the overall system efficiency and energy performance. A variable refrigerant flow (VRF) system with heat recovery is typically a three pipe system that have the ability to simultaneously heating certain zones and while cooling others, yielding the efficiency up to 14 EER.
Predicted Energy Use

An energy model was created using information available from the design team, including: drawings, schedules, and predicted occupancy. The Trane TRACE 700 energy simulation engine to predict annual energy use. The results are outlined in the tables and chart below, and are used to size the renewable energy systems for the project.

<table>
<thead>
<tr>
<th>End Use</th>
<th>Energy Use</th>
<th>EUI (kWh/SF/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>23,581 kWh</td>
<td>0.7</td>
</tr>
<tr>
<td>Cooling</td>
<td>95,808 kWh</td>
<td>2.7</td>
</tr>
<tr>
<td>Ventilation</td>
<td>87,234 kWh</td>
<td>2.4</td>
</tr>
<tr>
<td>Lighting</td>
<td>67,119 kWh</td>
<td>1.9</td>
</tr>
<tr>
<td>Receptacle</td>
<td>203,263 kWh</td>
<td>5.6</td>
</tr>
<tr>
<td>DHW</td>
<td>4,674 kWh</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>481,680 kWh</td>
<td>13.4</td>
</tr>
</tbody>
</table>

![Pie chart showing DHW 1.0%, Heating 4.9%, Cooling 19.9%, Receptacle 42.2%, Lighting 13.9%, and Ventilation 18.1%.]
Renewable Lifecycle Cost Analysis

- Predicted Site Energy Use
- Recommended 10% Safety Factor
- Solar Energy Generation

$1.1 Million Net Return by 2040

$100,000 Electricity Cost Savings per Year

System Paid Off in 2028

$1.2 Million Initial Investment
Carport mounted

Roof mounted
Overview of roof and carport PV
ZNE defined, measures adopted

**Definition**

Predicted Site Energy Use: 481,680 kWh

Recommended 10% Safety Factor

Solar Energy Generation: 354,377 kWh (Rooftop), 171,828 kWh (Carports), total 529,848 kWh

**Measures**

- Window glazing replacement
- Solar shading louvers
- Daylighting system including LED fixtures
- High-efficiency heating & cooling system (VRF)
- Heat Pump Hot Water
- Photovoltaics

BONUS!: Solar on adjacent tenant space connected to police station meter, tenant can utilize 10% excess generation capacity….
New entry element built with straw bales, a renewable resource.
Welcoming service point for police services... legible and accessible to the community.
Step 1

Step 2

Finished! Strawbale R-40

Step 3
Daylighting
Schematic floor plan...
Developed floor plan...
Ceiling plan showing skylights...
Roof plan showing PV coordinated with skylights...
Planned ZNE installation...
Project Status and Financing Options

- Project now in final design, bids due in mid-February. ZNE photovoltaics are a bid alternate estimated at $1.1 million, paid for by project funds.

- General Contractor would be responsible for integrating into the project, panels City-owned.

- City has options. It can accept the bid alternate, or
  - proceed with a standalone PV bid,
  - switch to a power purchase agreement (PPA),
  - go for an Energy Saving Performance Contract (ESCO),
  - other.